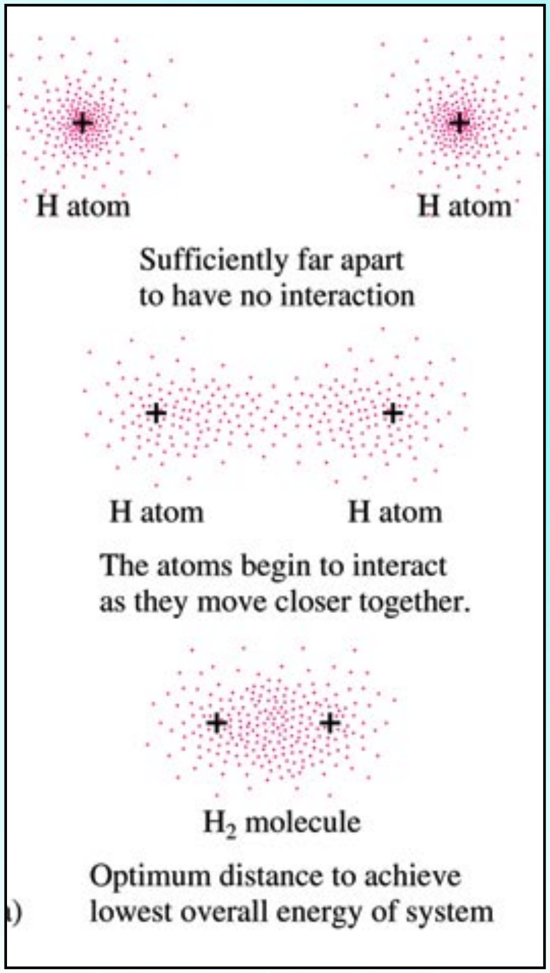
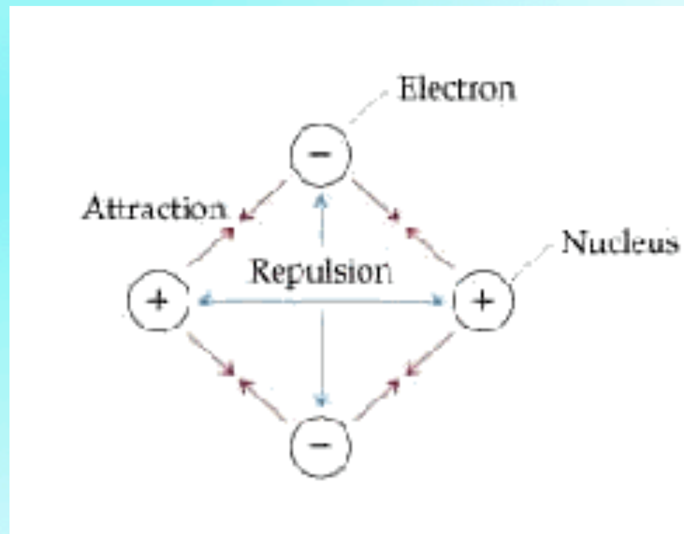
# Chapter 6: Bonding

Chemical Bond - link b/w atoms that results from a mutual attraction of their nuclei for $e^-$



Three Kinds of Bonds

Ionic - electrostatic link b/w positive and negative ions

Forms through **TRANSFER OF ELECTRONS**

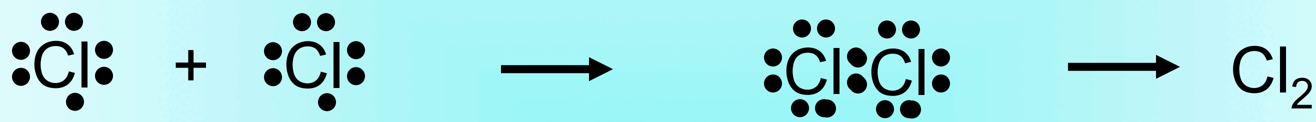
$$Na\cdot \; + \; :\overset{\cdot\cdot}{\underset{\cdot}{Cl}}: \; \longrightarrow \; Na^{+} \; + \; :\overset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}:^{-} \; \longrightarrow \; NaCl$$

Ionic Bonds form between: Metals and Nonmetals

Metals and Polyatomic Ions

## Three Kinds of Bonds (con't)

Covalent - electrostatic link resulting from sharing of $e^-$




Covalent Bonds form between: Nonmetals and Nonmetals
Within Polyatomic Ions

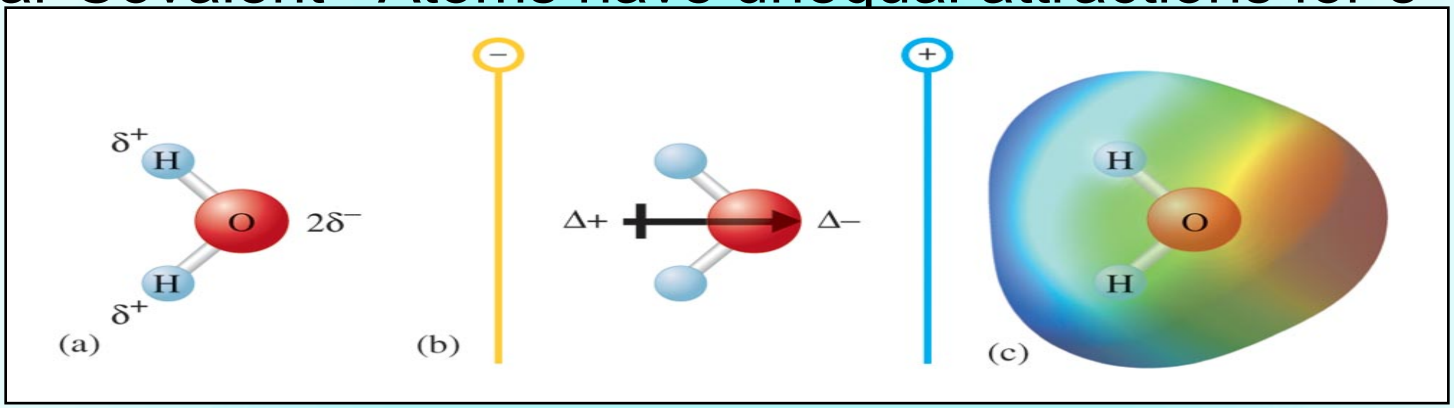
Metallic - Bonds between metal atoms

# More on Covalent Bonds

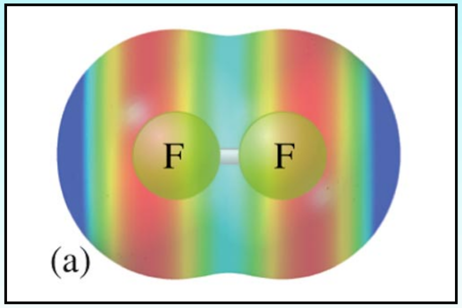
There are varying degrees of covalent bonds because atoms attract electrons differently

Differences in electronegativity allow for how $e^-$ are distributed across bonds

Polar Covalent - Atoms have unequal attractions for $e^-$




Nonpolar Covalent - Atoms have equal attractions for $e^-$



# How Do You Tell?

By the difference in electronegativity

If the difference in e-neg between two atoms in a bond is b/w:

0.0 - 0.3 : Nonpolar Covalent

0.3 - 1.7 : Polar Covalent

1.7 - 3.3 : Ionic

Are the bonds in the following compounds Ionic, Polar, Nonpolar Or Both

| | |
|---|---|
| $CaCl_2$ | $NaNO_3$ |
| $CO$ | $I_2$ |
| $HF$ | $OCl_2$ |

# Covalent Bonding and Molecular Comps

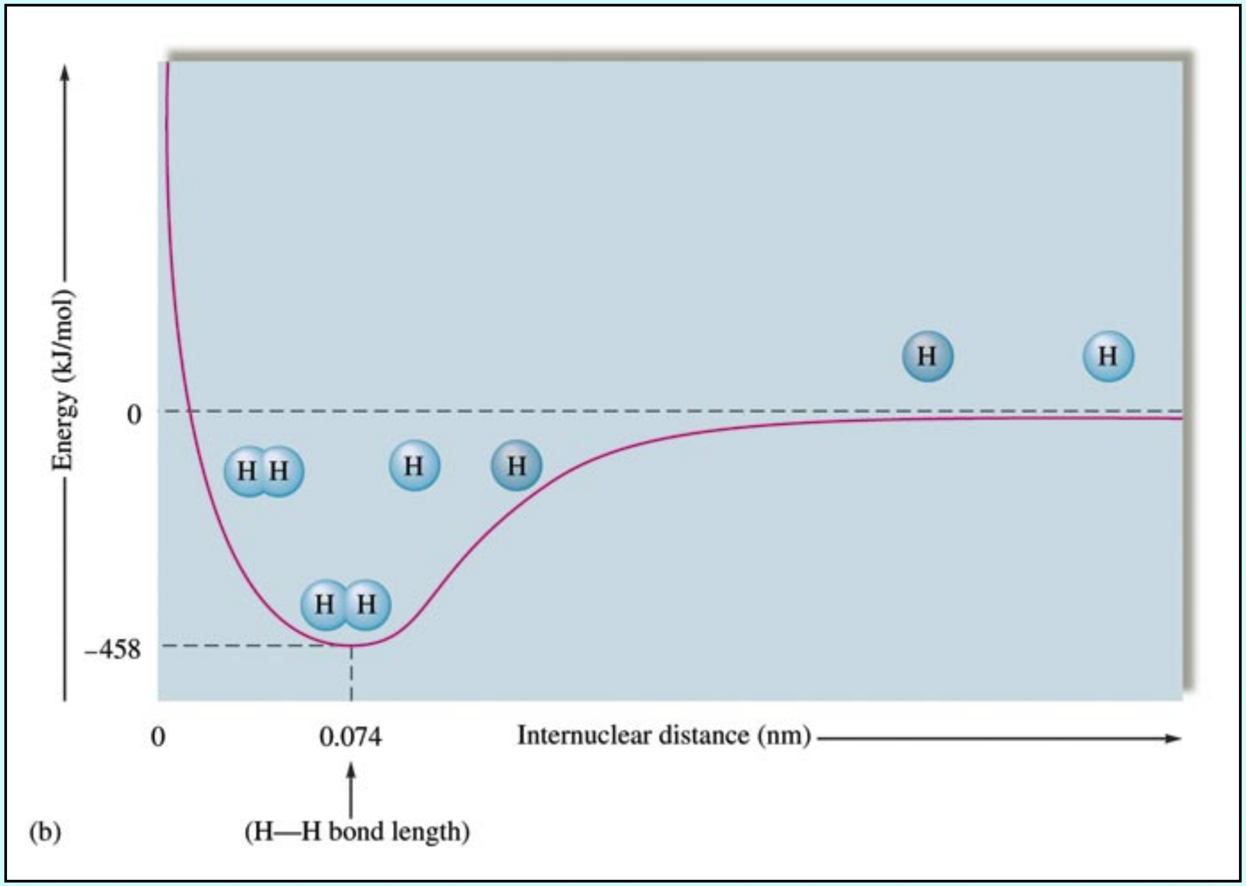
**Molecule** - group of two or more atoms held together by covalent bonds and <u>able to exist independently</u>

**Chemical Formula** - Shorthand representation of the composition of a substance using atomic symbols and numbered subscripts

$H_2O$ $H_2$ $C_6H_{12}O_6$

Why bonds form?

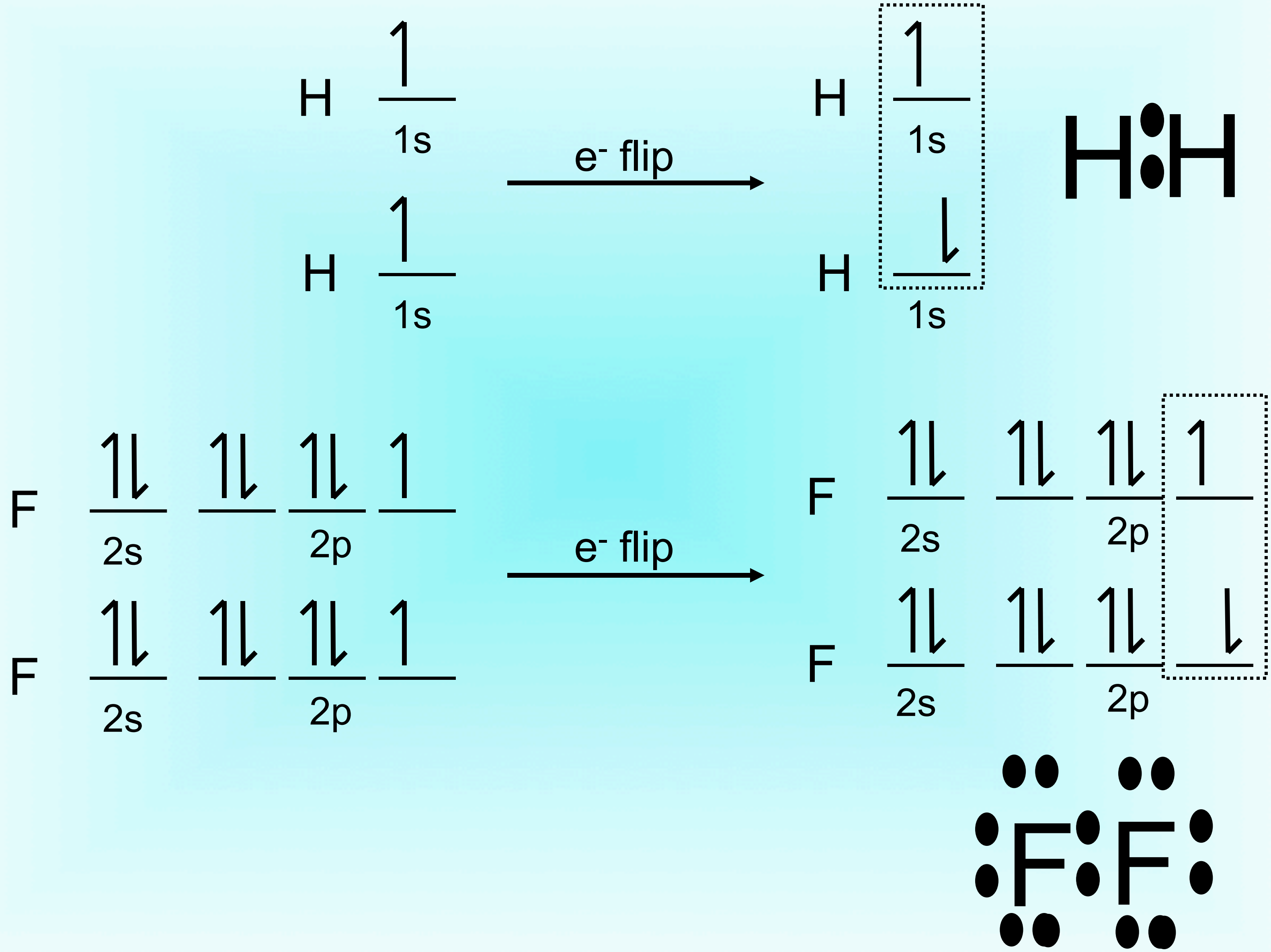
So the atoms get to the lowest PE



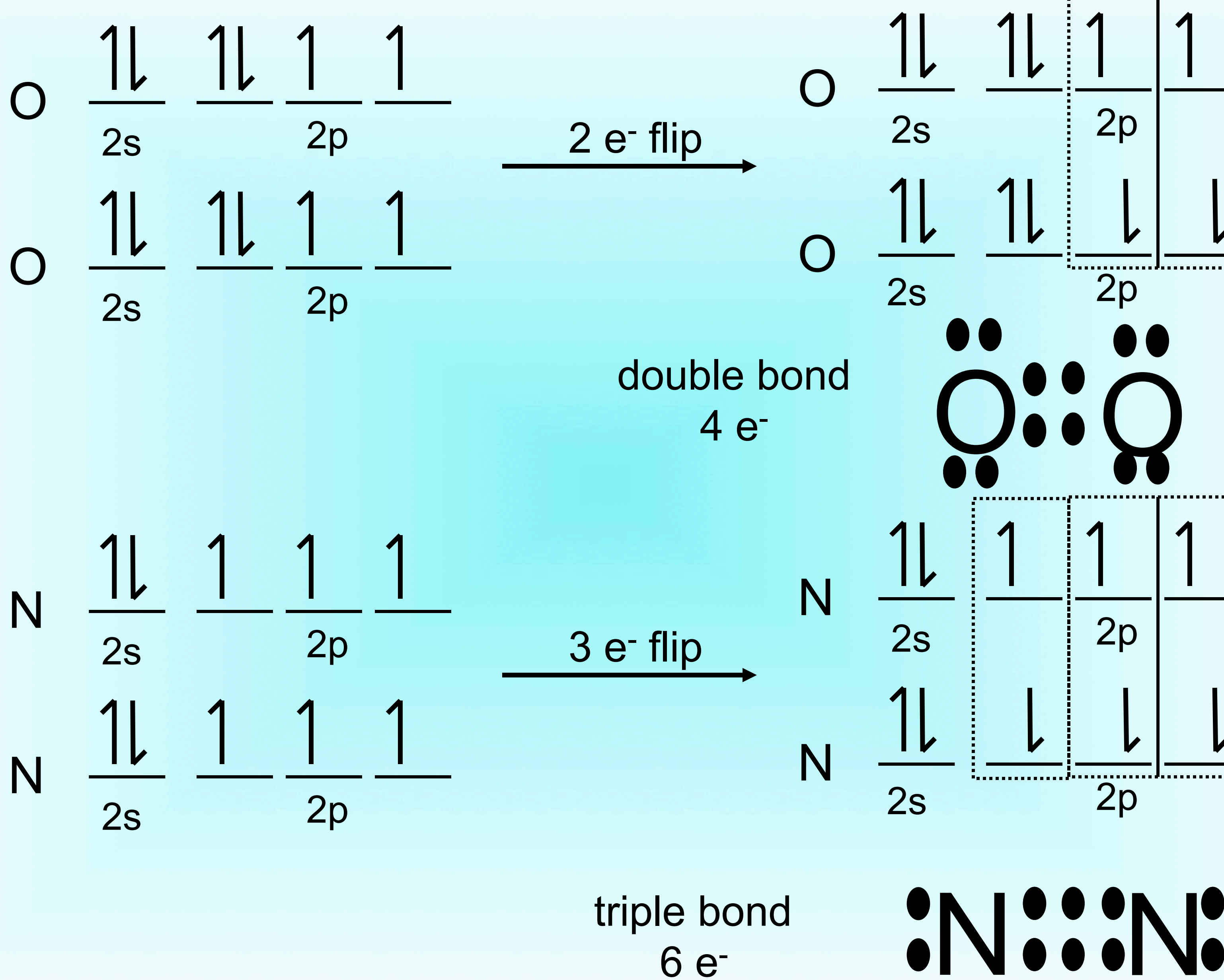

Bond E - E req'd to break a chemical bond

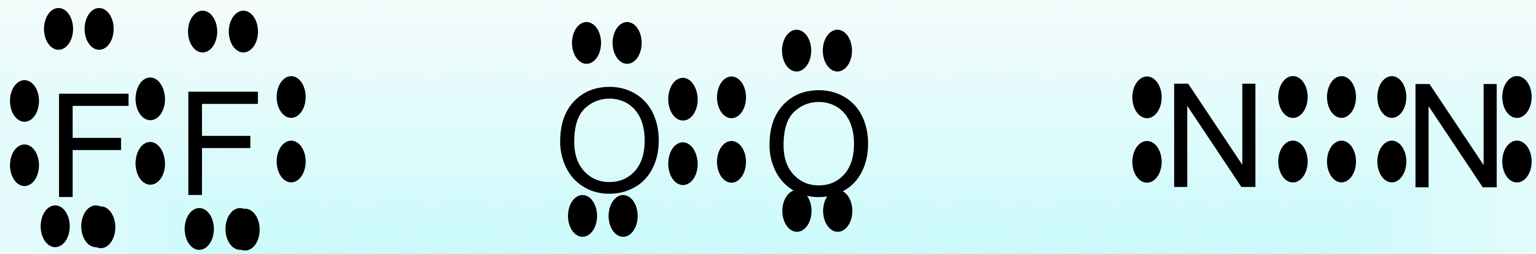
Bond Length -duh

# What happens when a bond forms?

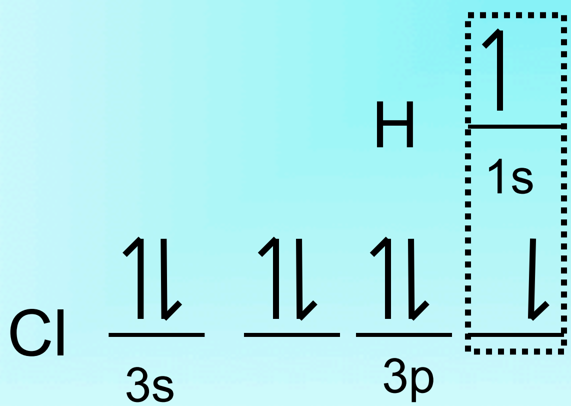


# Other atoms…






**Octet Rule -** compounds form so that each atom, by either gaining, losing, or sharing $e^-$, has an octet of $e^-$ in its highest E-level




# Drawing Lewis Structures

1. Determine the total number of valence electrons from the atoms present
2. Arrange the atoms in a skeleton structure with the least e-neg atom in the middle

   H is never central
   C is 99% central

3. Add pairs of $e^-$ b/w each atom (shared pair)
4. Add unshared pairs of e- to each nonmetal so they have octets
5. Check math (if too many electrons try multiple bonding)

$CH_3I$ $NH_3$ $SiF_4$

$CH_2O$ $PO_4^{3-}$ $NH_4^+$

# Quick Rules for Drawing Lewis Structures

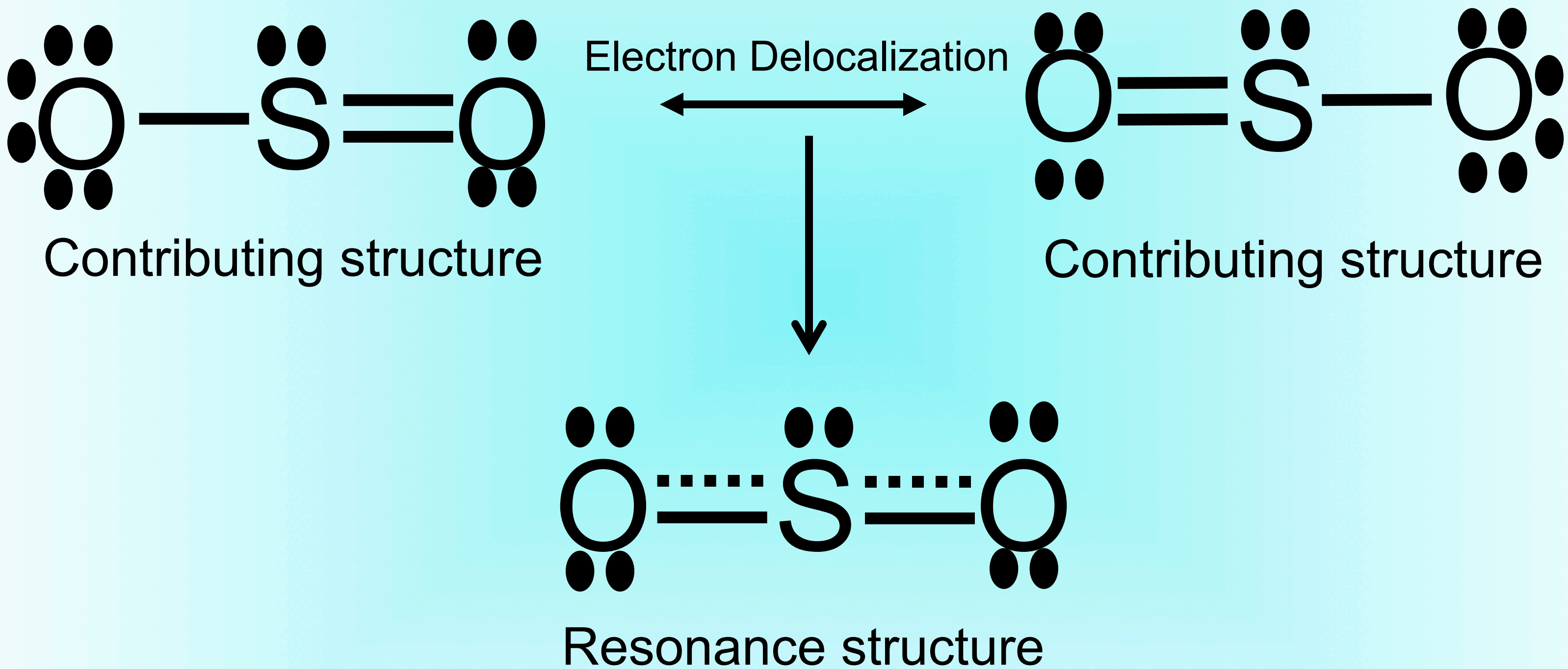
these work most of the time

| Elements | # of Bonds | # of unshared $e^-$ pairs |
|---|---|---|
| H | 1 | 0 |
| C | 4 | 0 |
| N | 3 | 1 |
| O | 2 | 2 |
| Halogens | 1 | 3 |

# Resonance

(only worry about it when indicated)

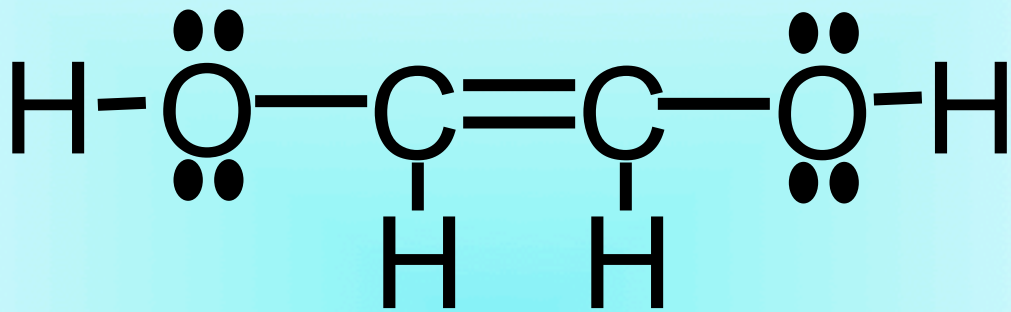
Molecules can be represented by more than one Lewis x-ture

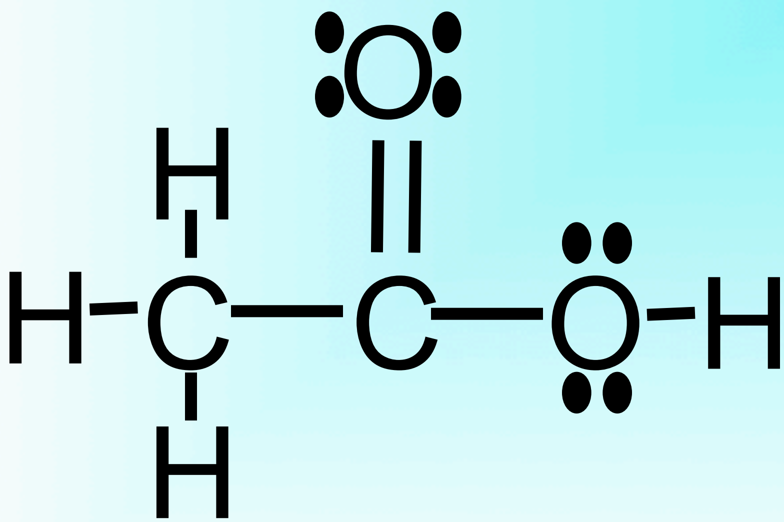


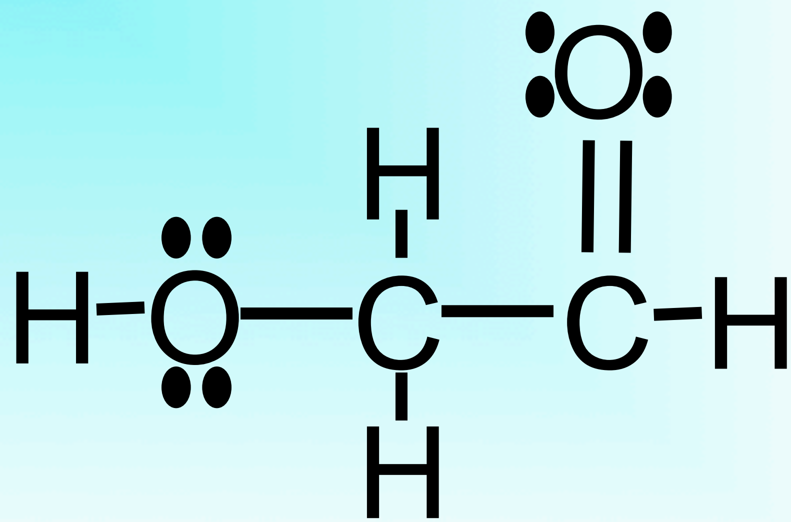
Isomers

Same molecular formula but different structural formulas

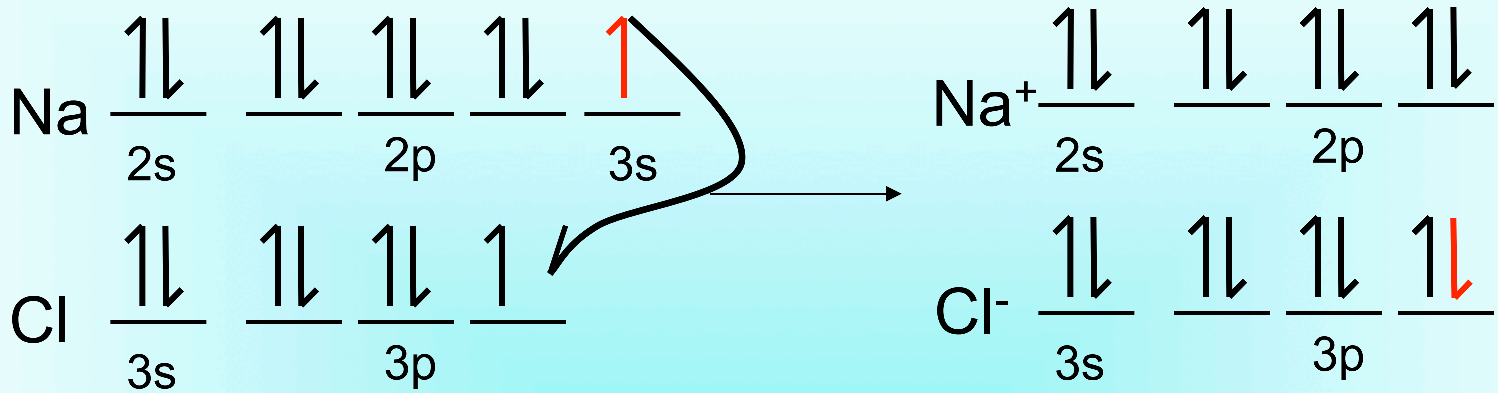
Molecular Formula - $C_2H_4O_2$





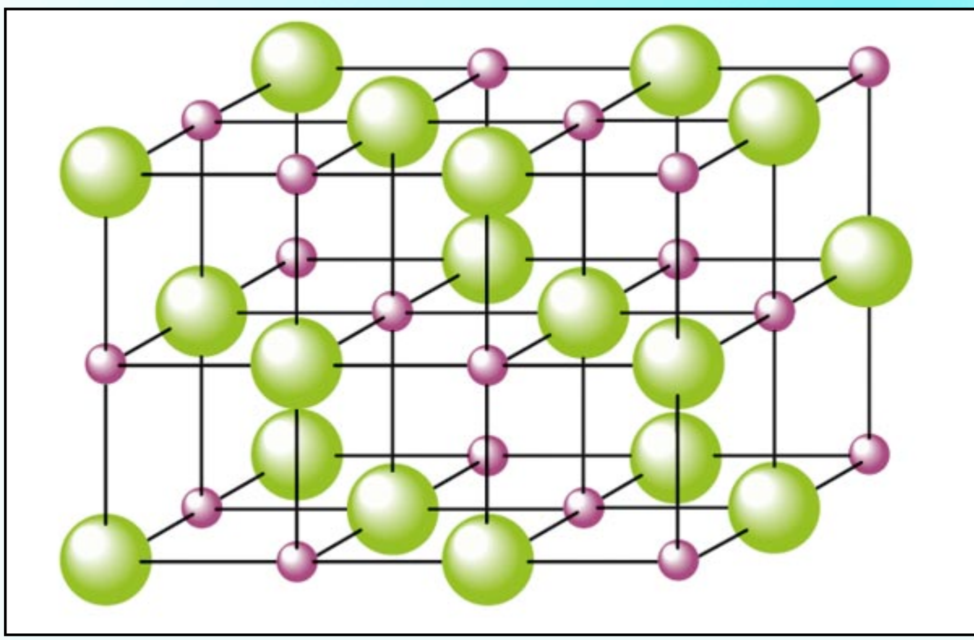


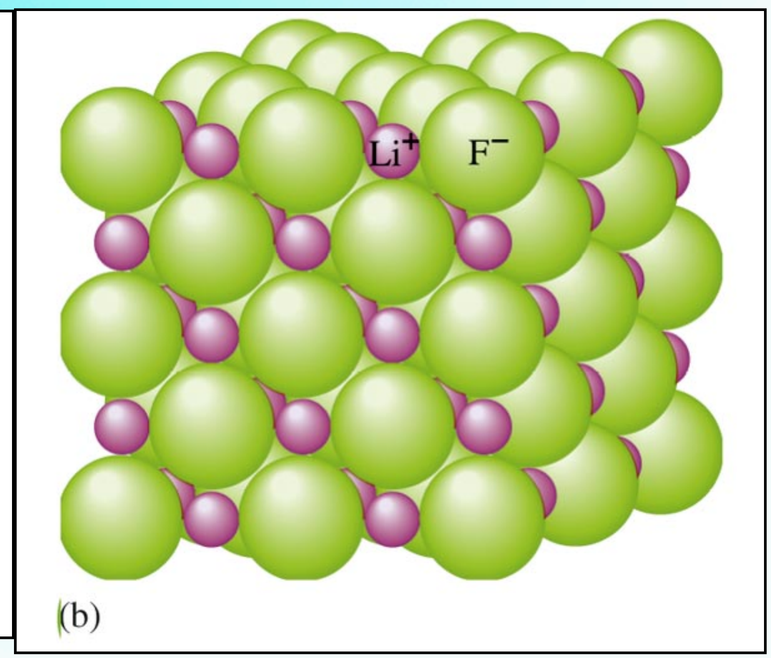
# Ionic Bonding




Crystal Lattice

NaCl





# Properties of Ionic Compounds

Lattices are “**closest packed”**

Brittle

High Melting and Boiling Points

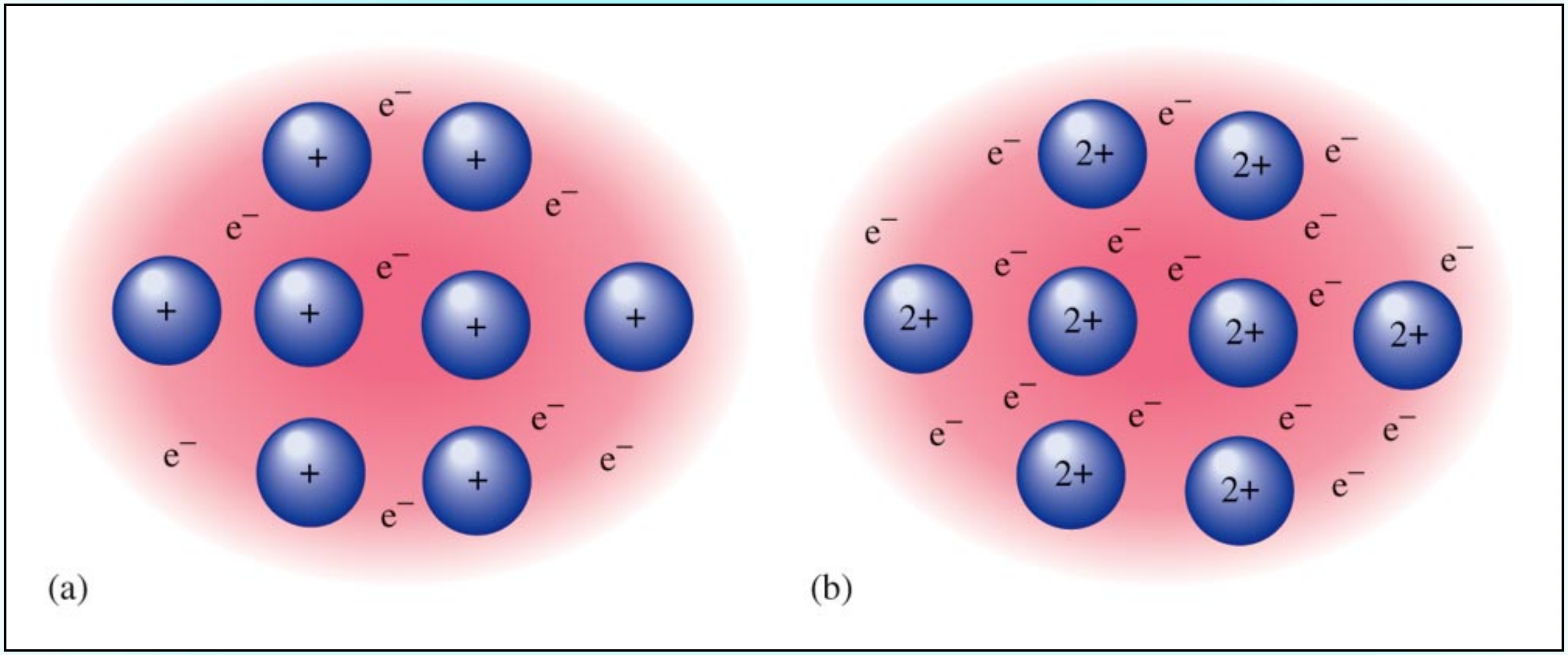
| | MP ($^oC$) | BP ($^oC$) |
|---|---|---|
| NaCl | 801 | 1413 |
| $C_{12}H_{22}O_{11}$ | 186 | - |

Charges allow them to dissolve in water

# Metallic Bonding

**Electron Sea Model**

Valence e- are given up and shared b/w all atoms in sample of a metal.  The electrons are not localized to any one atom




This why metals are malleable, ductile, and conductive

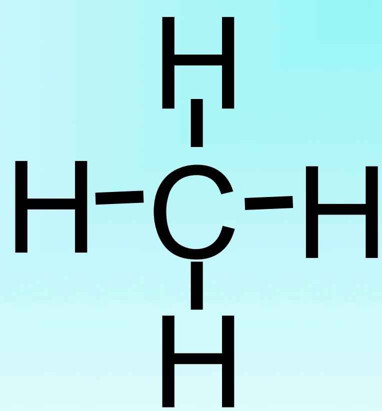
Properties of compounds depend on two things:

Types of Bonds - Ionic or Covalent

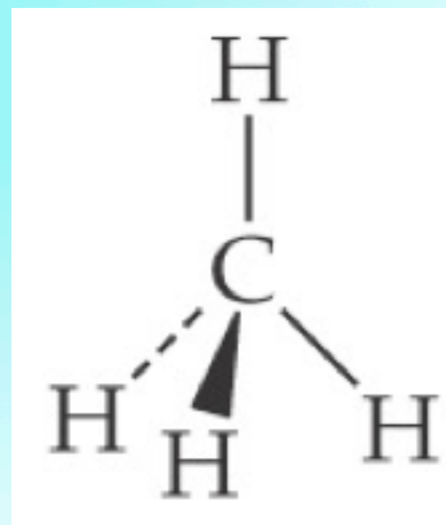
Geometry - 3D shapes of molecules

VSEPR - Valence Shell Electron Pair Repulsion

3D Geometry of molecules based on electrostatic repulsion of $e^-$, (Bonds angle themselves to be as far apart as possible)

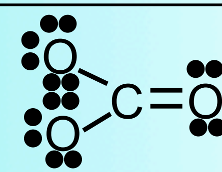
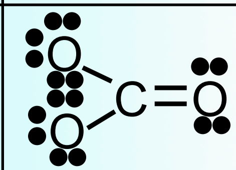
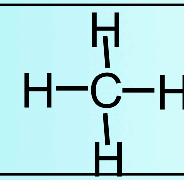
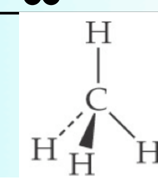
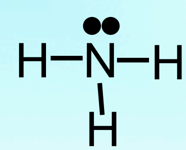
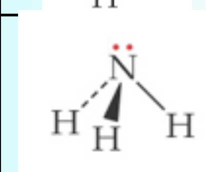
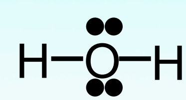
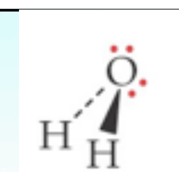



$90^o$ Bond Angle

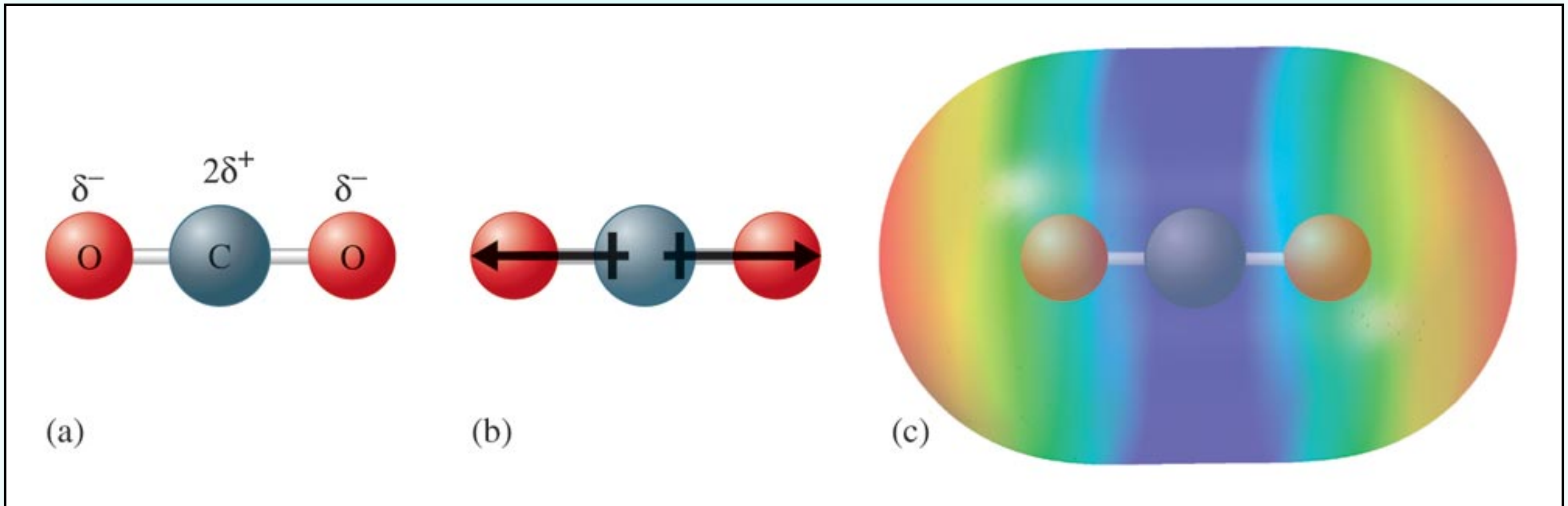


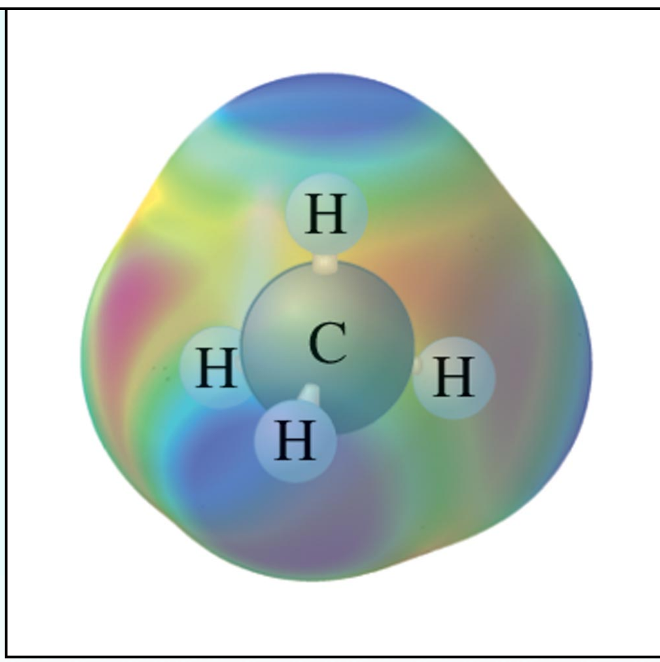

$109.5^o$ Bond Angle

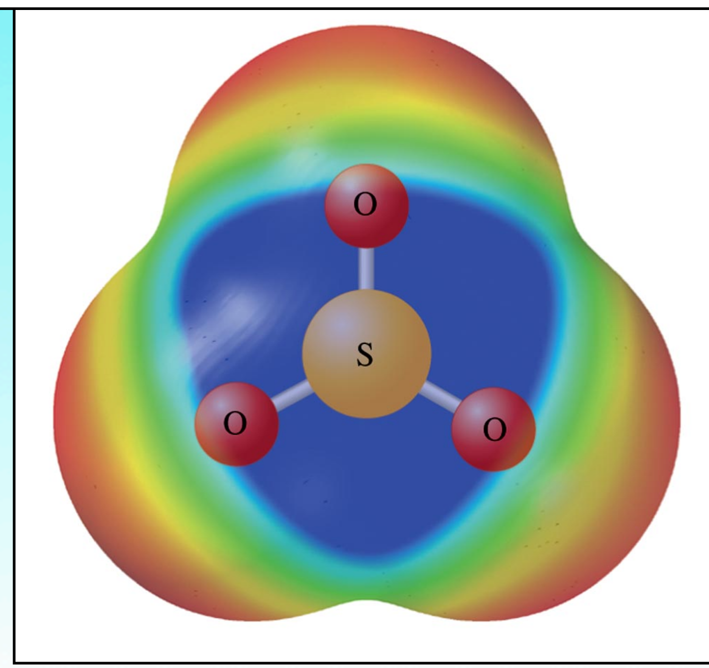
# VSEPR Table

| Molecule Type | # unshared e- pairs on central atom | Geometry Type | Bond Angle | Example | Lewis Structure | 3D Structure |
|---|---|---|---|---|---|---|
| $A_2$ | ______ | Linear | ______ | $H_2$ | H−H | H−H |
| $AB_2$ | 0 | Linear | 180° | HCN | H−C≡N: | H−C≡N: |
| $AB_3$ | 0 | Trigonal Planar | 120° | $CO_3^{2-}$ |  |  |
| $AB_4$ | 0 | Tetrahedral | 109.5° | $CH_4$ |  |  |
| $AB_3E$ | 1 | Trigonal Pyramidal | 107° | $NH_3$ |  |  |
| $AB_2E_2$ | 2 | Bent | 105° | $H_2O$ |  |  |

# Symmetry Cancels out Polarity



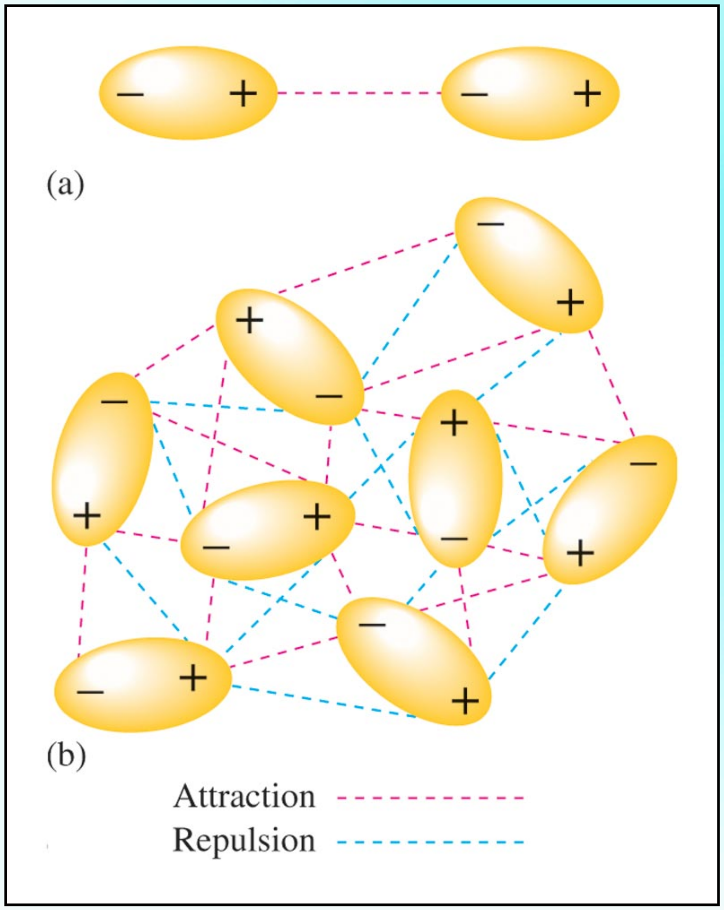



Intermolecular Forces - attractive forces b/w molecules

These are not bonds, just weak forces of attraction.

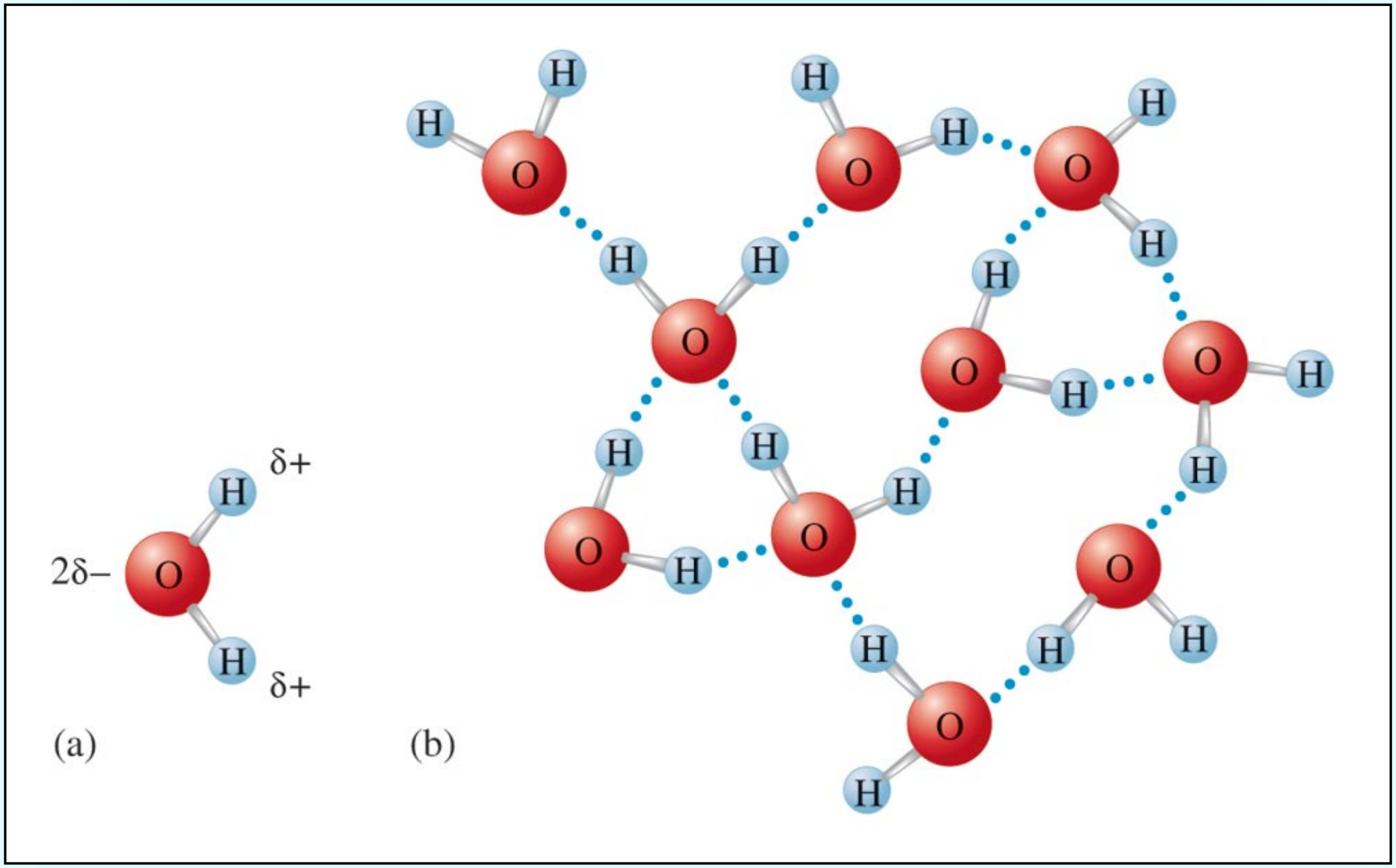
1. Dipole-Dipole Interactions - Attractive forces between polar molecules

Dipole - Equal but opposite charges separated by short distance

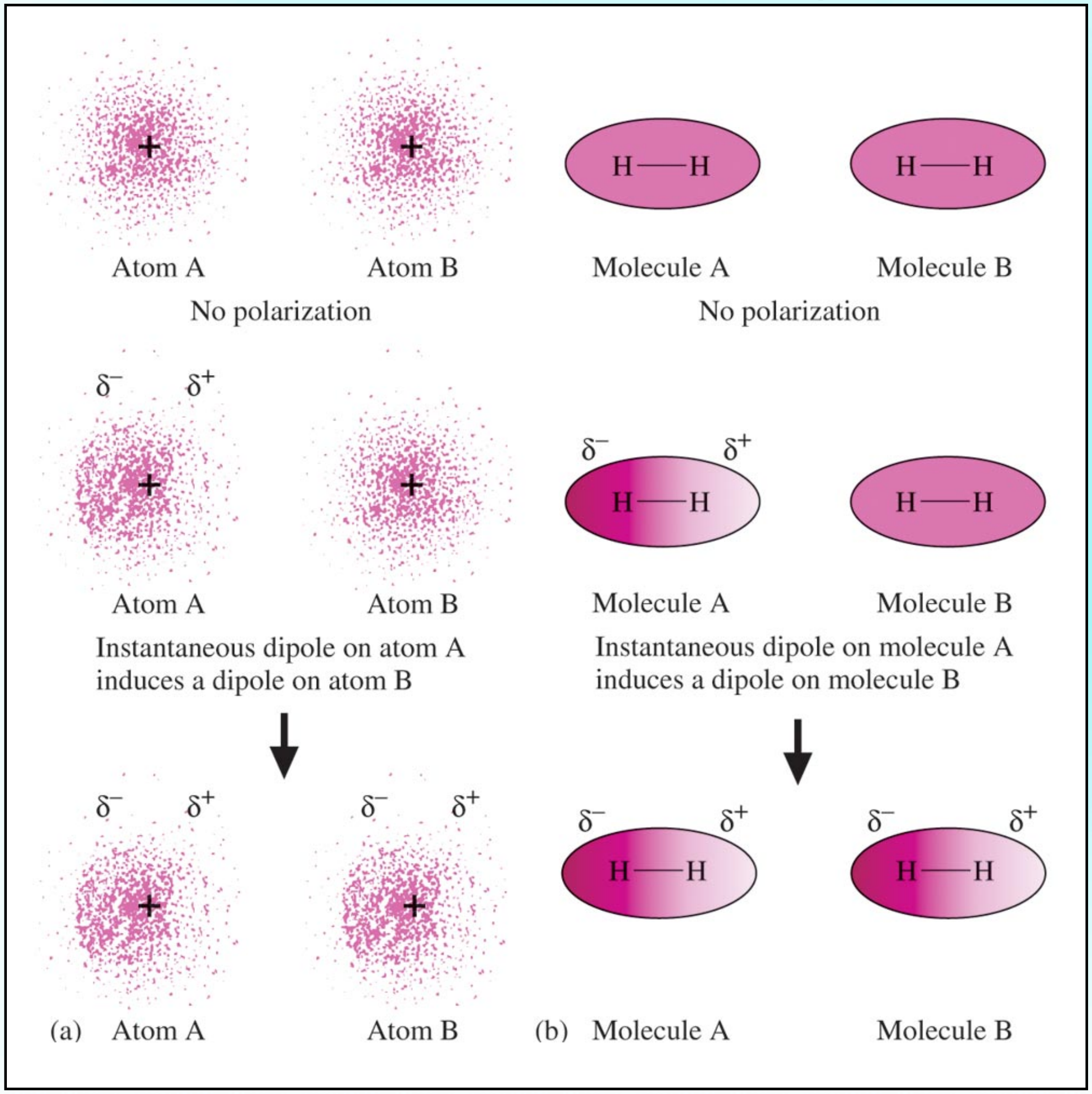



| Compound | Boiling Point |
|---|---|
| Cl-Cl | $-34^{o}C$ |
| I-Cl | $97^{o}C$ |

2. Hydrogen Bonding - Attraction between a H bonded to a strong e-neg atom and an unshared pair of $e^-$ on another strongly e-neg atom.



3. London Dispersion Forces - IM Forces b/w nonpolar molecules and atoms. Caused by random motion of e- to create instantaneous and induced dipoles.




The more $e^-$, the stronger the dipoles created

| | Boiling Point |
|---|---|
| He | -269$^o$C |
| Ar | -186$^o$C |